Integrating Behavioral Health into Recommendations for Future Exploration Habitats

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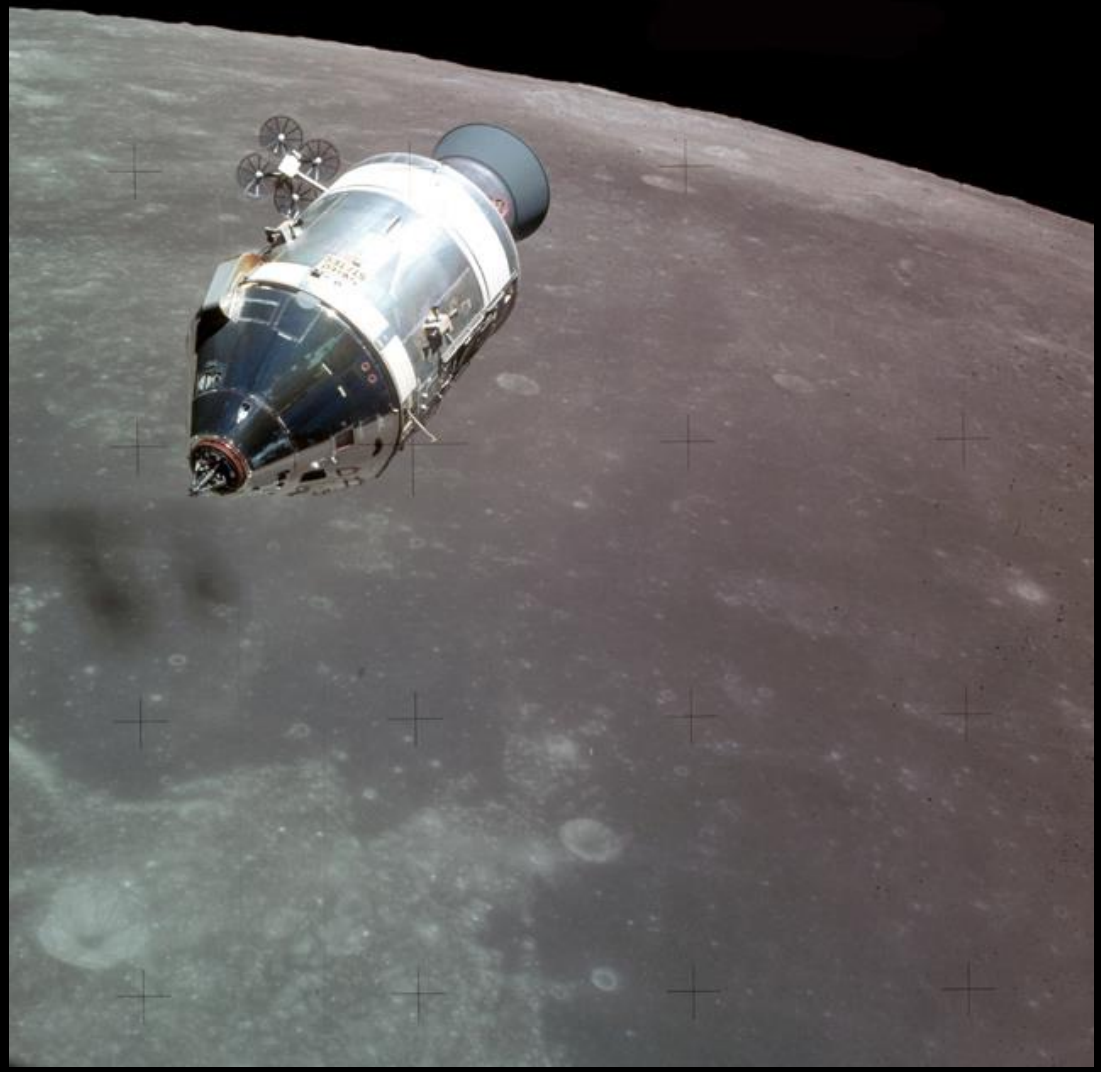
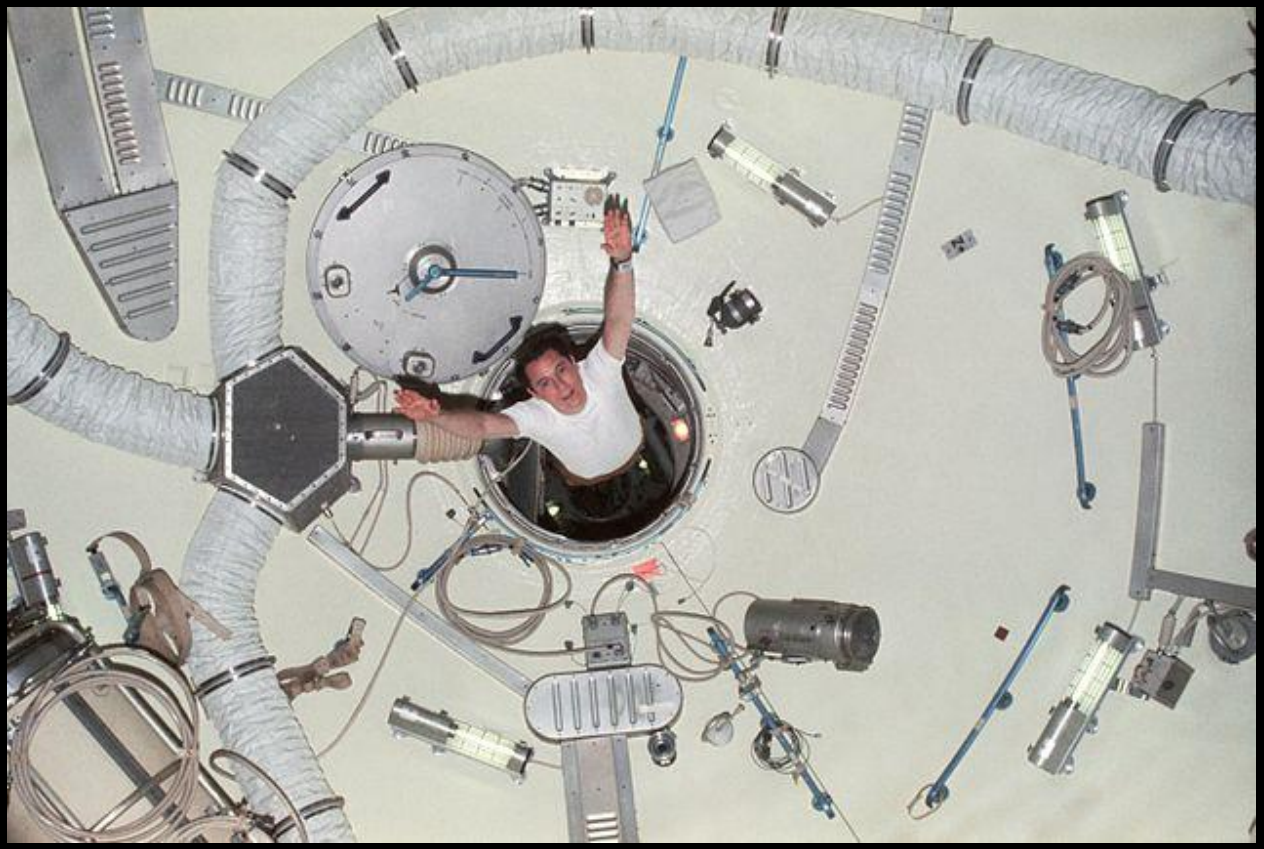
Mission	Habitable Volume (m^3/person)	Maximum Mission Duration
Gemini	1.28	14 days



Mission	Habitable Volume (m^3/person)	Maximum Mission Duration
Apollo	3.33	9 days

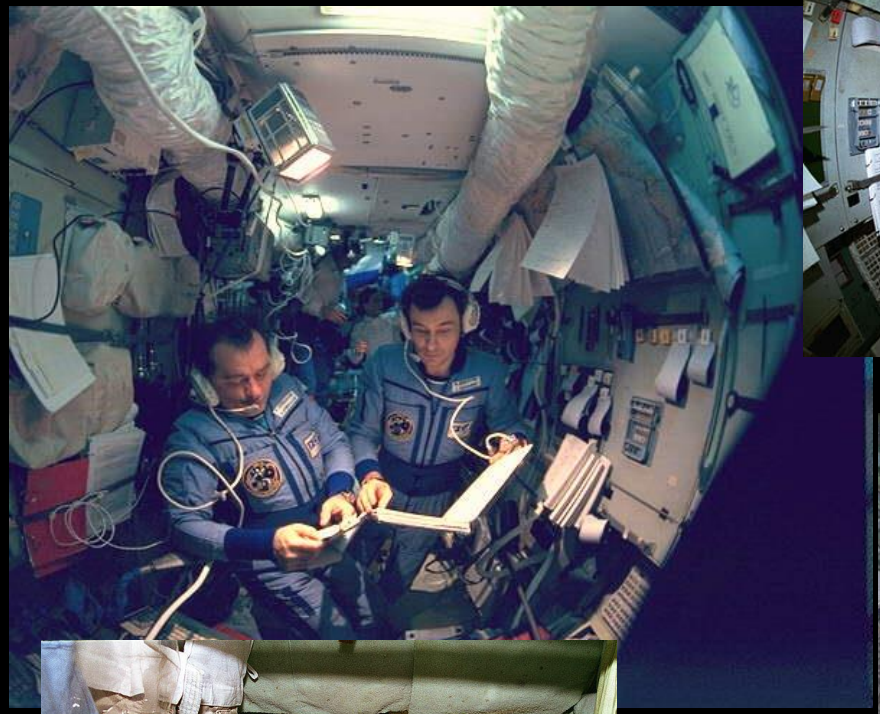
Skylab

Mission	Habitable Volume (m^3/person)	Maximum Mission Duration
Skylab	120.33	84 days



Mir

Mission	Habitable Volume (m^3/person)	Maximum Mission Duration
Salyut	45	438 days




To NOD 3
To HAB


FRANK CALDEIRO
WARNING
EQUALIZE
LATCHED
Foam Food Locker
CONDIMENTS

Historical Approach: Long-Duration Missions (> 30 days)

Long Duration Mission	Hab Volume (m3/person)	Maximum Mission Duration
Skylab	120.33	84 days
ISS	85.17	342 days
- Crew Quarters	2.1	
Salyut	33.5	237 days
Mir	45	438 days

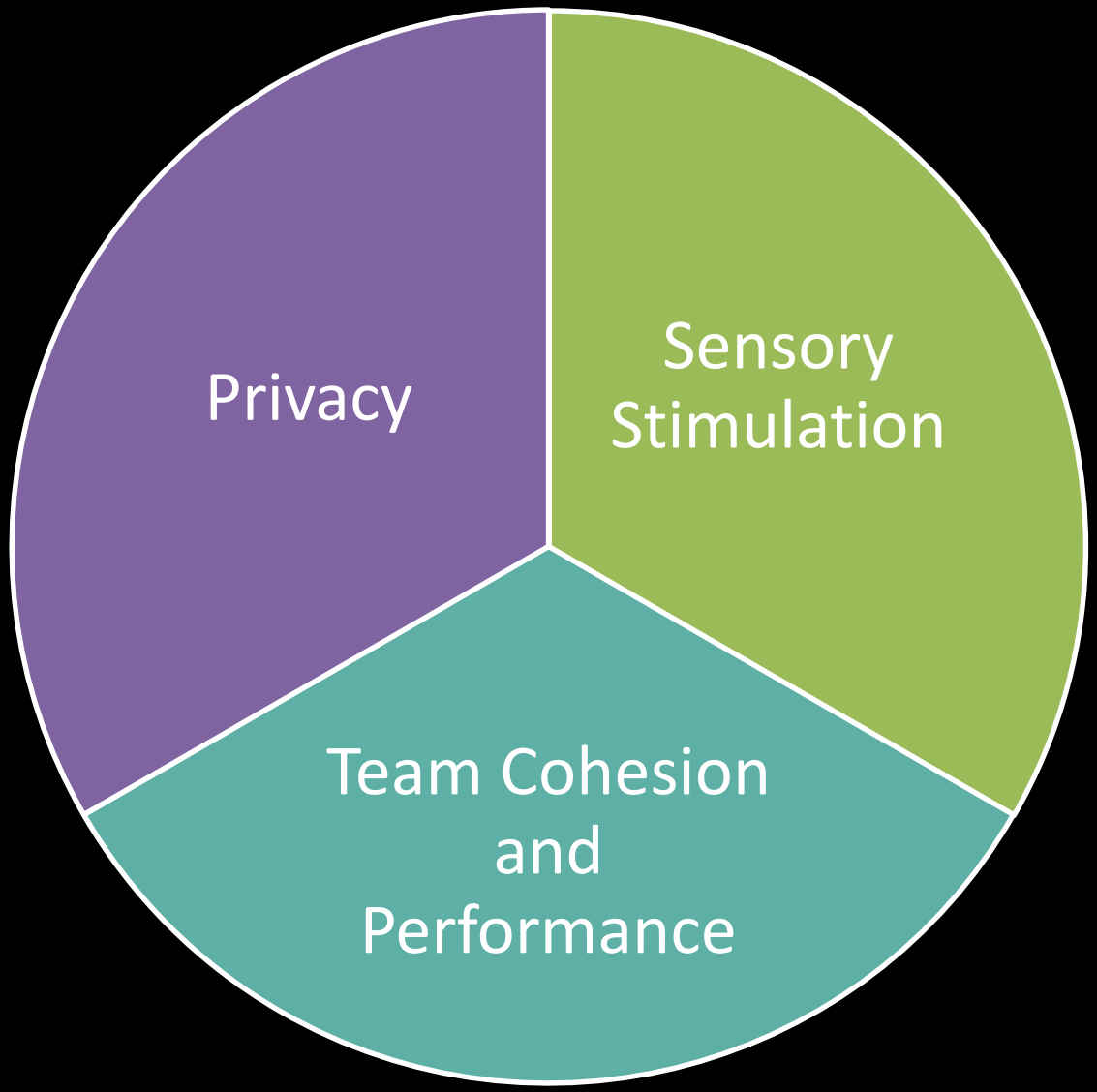
Habitable Volumes of Historical Long Duration Missions (> 30 days)

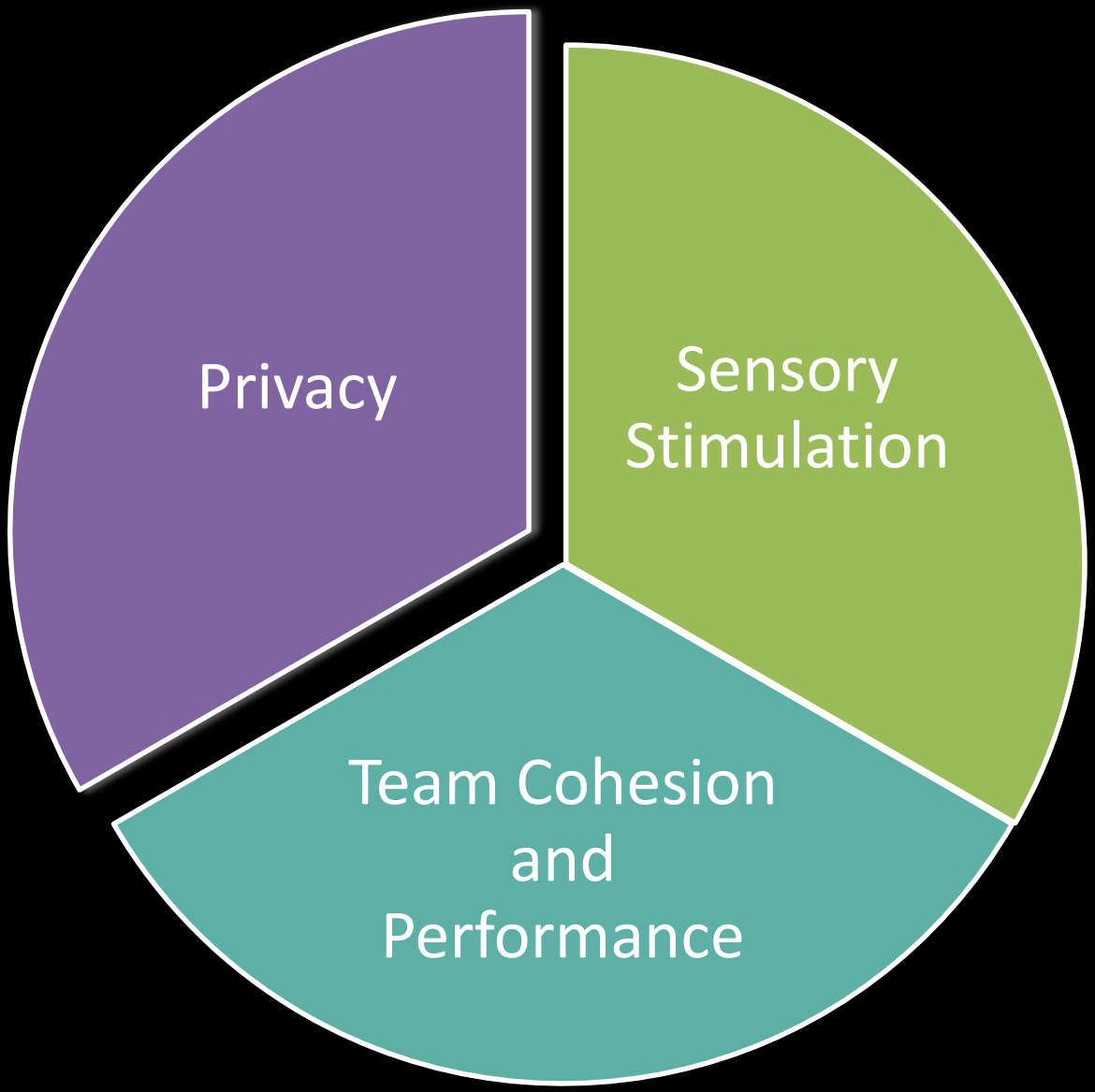
Mars Scenario
Design Reference Mission 5.0

Characteristic	Mars DRM 5.0
Total Mission Duration	30 Months
- **In transit to**	6 months
- **At target**	18 months
- **In transit from**	6 months
Crew Size	N = 6
Crew Composition	Pilot, Physician, Geologist, Biologist, Engineer, Electrical Engineer
Gender Composition	Variable; exact mix undefined
Cultural Composition	Presumably some combination of US, Russia, Europe, Canada and Japan
Mission Tempo	Long periods of low mission tempo, interspersed with high activity times (e.g. launch, jettison tanks, dock, landing)
Communication Delays	Up to 22 minutes one-way with blackout periods
Autonomy from Ground	Increasing en route to Mars, decreasing during return to Earth

Example Exercise Volumes						
PARAMETERS AND SOURCES			TASK VOLUME			
Source	Op Scenario	No. Of Crew	Footprint		Height (m)	Volume (m^3)
			Length (m)	Width or Area (m or m^2)		
JACK model ISS ops	Aerobic- T2	1	1.38	1.03	2.12	3.02
	Resistive- ARED	1	1.44	1.20	2.64	4.60
HIDH	Aerobic-treadmill	1	2.37	1.23	2.10	6.13
	Aerobic-ergometer	1	1.43	1.23	0.97	1.71
ABS	Aerobic, flexibility, strength station deck area	1	------	1.86	1.98	3.68
HSIR	Rower	1	1.31	1.01	2.23	2.93

How do we incorporate *behavioral* aspects into our volume and design recommendations?


Privacy
Sensory Stimulation
Team Cohesion and Performance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Privacy

Having an acceptable level of control over the extent of sharing oneself (physically, behaviorally, or intellectually) with others

- Evidence from Antarctica indicates individuals need to be able to “get away” from others from time to time (Stuster, 1996)

How can the vehicle facilitate privacy?

- Example: Acceptable individual crew quarters in vehicles that support long duration missions

Privacy

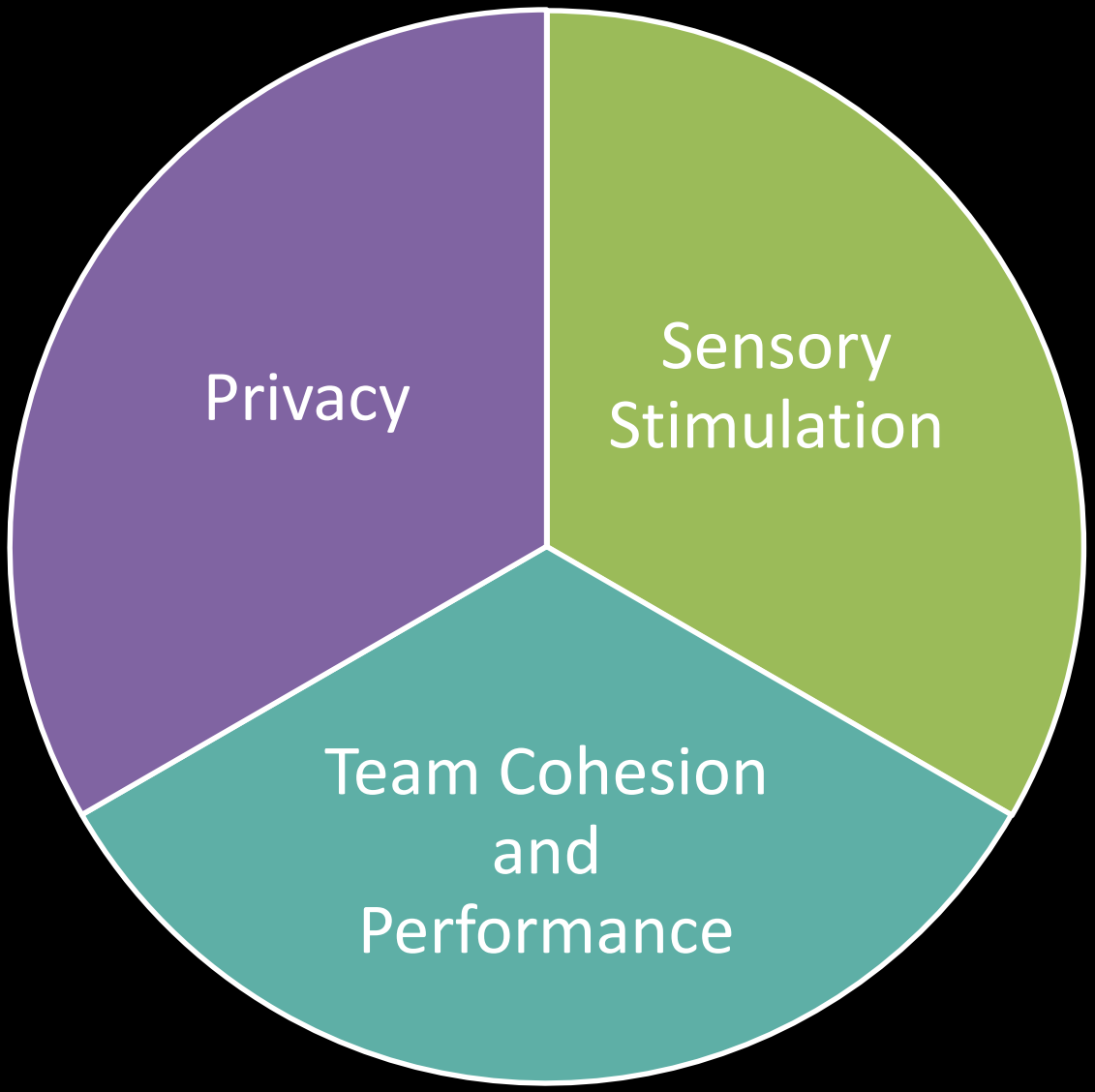
What assessments/studies are needed?

- Aiken (2015) defines tasks requiring privacy; for example, waste management, communications with home

Task by task assessment of volume needs, relative to the vehicle via:

- Review of specifications?
- Test through virtual reality?
- Test in a mock-up?

- Evaluate in a research study: size and configuration relative to remainder of habitat
  - Requires long duration?
  - Requires high-fidelity analog: restricted volume, isolation, confinement?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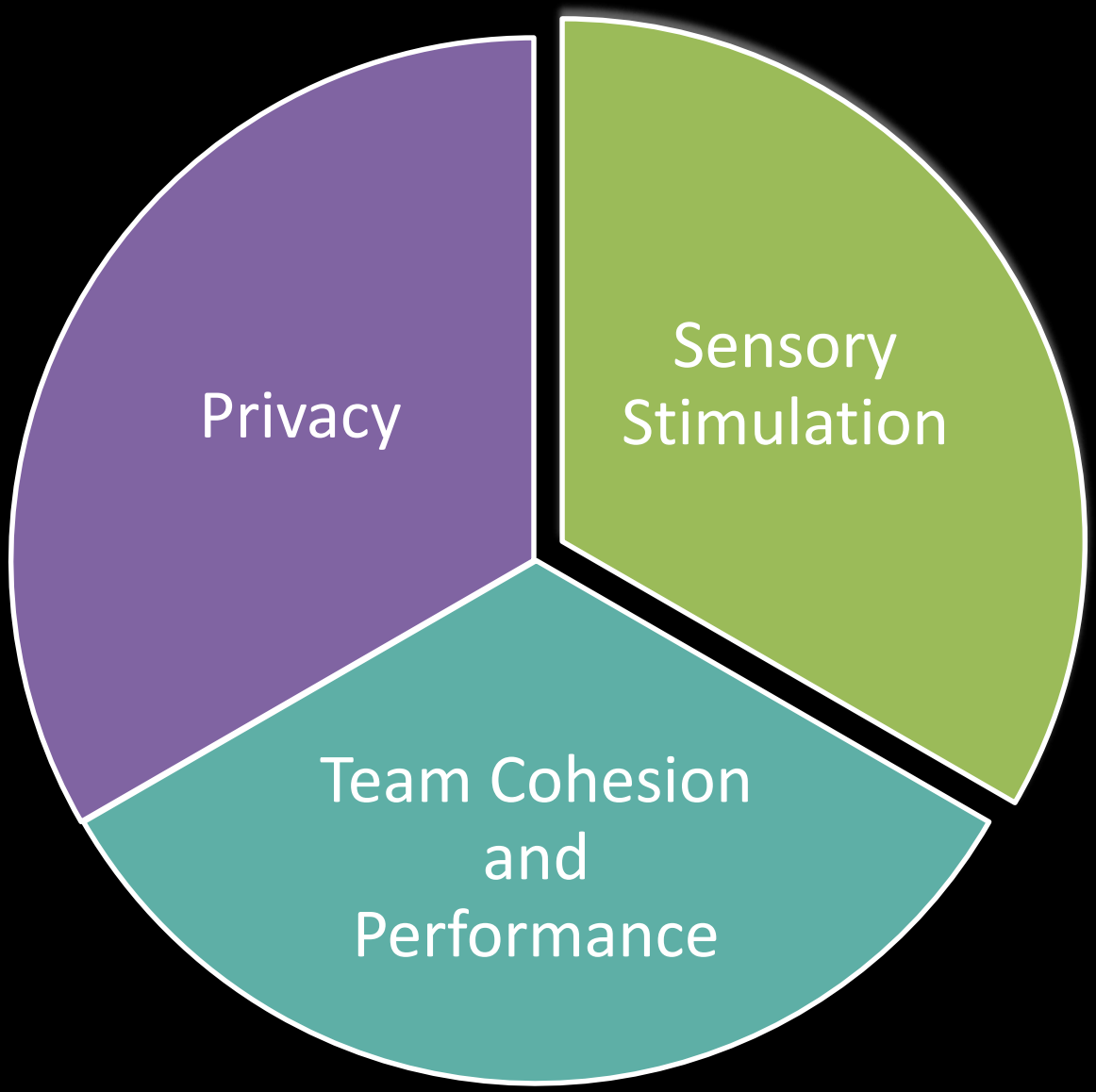
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Sensory Stimulation

Changes in the level and variation of sensory (visual, tactile, olfactory, gustatory, auditory) stimulation on behavior and physiology.

- Animals in captivity show signs of anxiety and stress, as measured by their behavior and physiology (Vessel, 2015)
  - Van Praag et al. (2000) report increases in brain weight, DNA/RNA content, and brain proteins such as growth factors and receptors in response to *environmental enrichment*
  - Evidence from analogs that isolation can lead to increased stress response; increased reports of boredom, loneliness, monotony (Bishop et al, 2010, as cited by Vessel, 2015)

How can the vehicle facilitate sensory stimulation?

- Examples: Windows, Virtual Reality; Equipment to facilitate meaningful work; Plant life

Sensory Stimulation

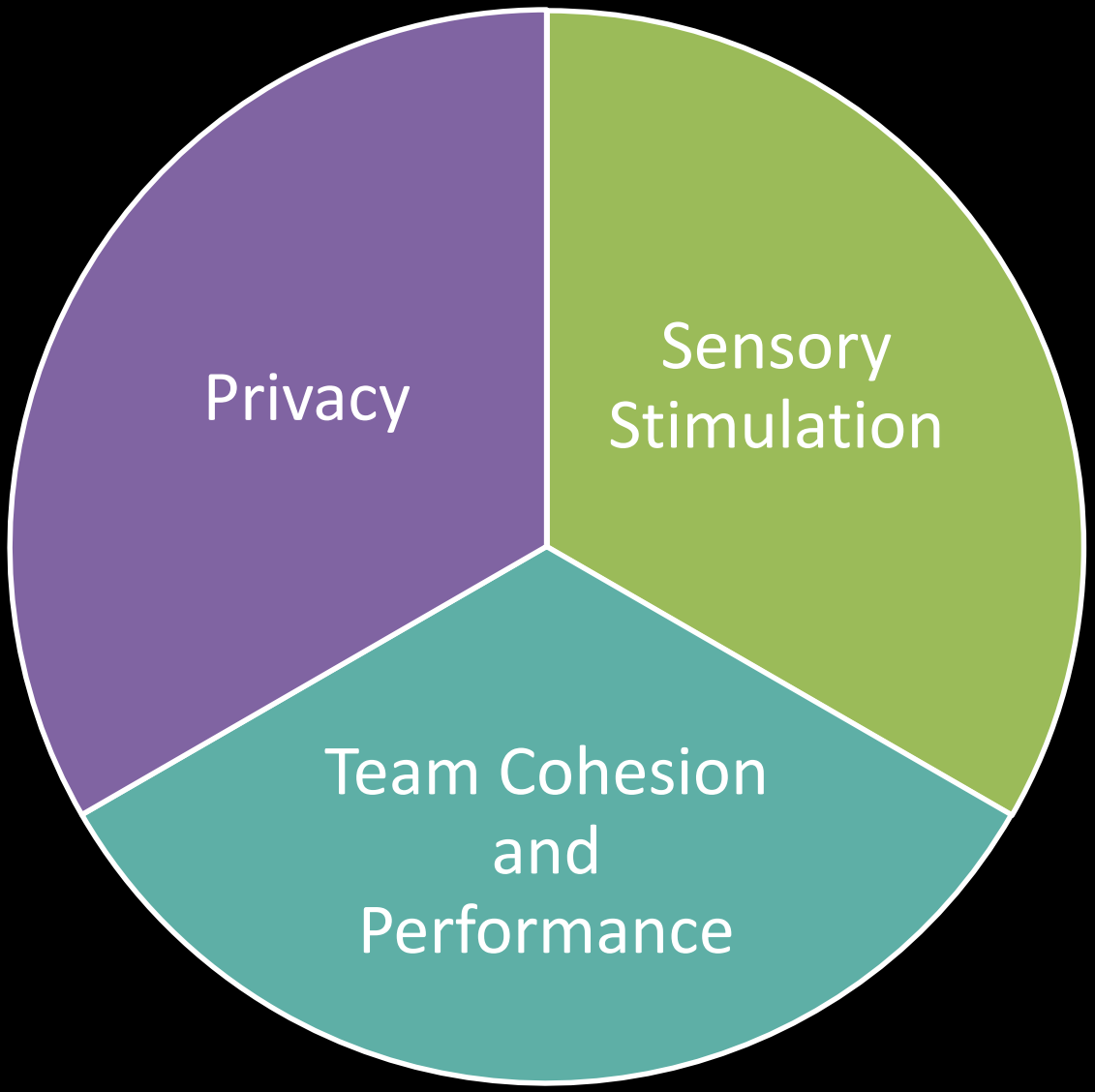
What assessments/studies are needed?

- Determine the right set of countermeasures and tools for future crews, in terms of quantity, dosage

Task by task assessment, relative to the vehicle via:

- Review of specifications?
- Test through virtual reality?
- Test in a mock-up?

- Evaluate in a research study
  - Requires long duration
  - Requires high-fidelity analog: restricted volume, isolation, confinement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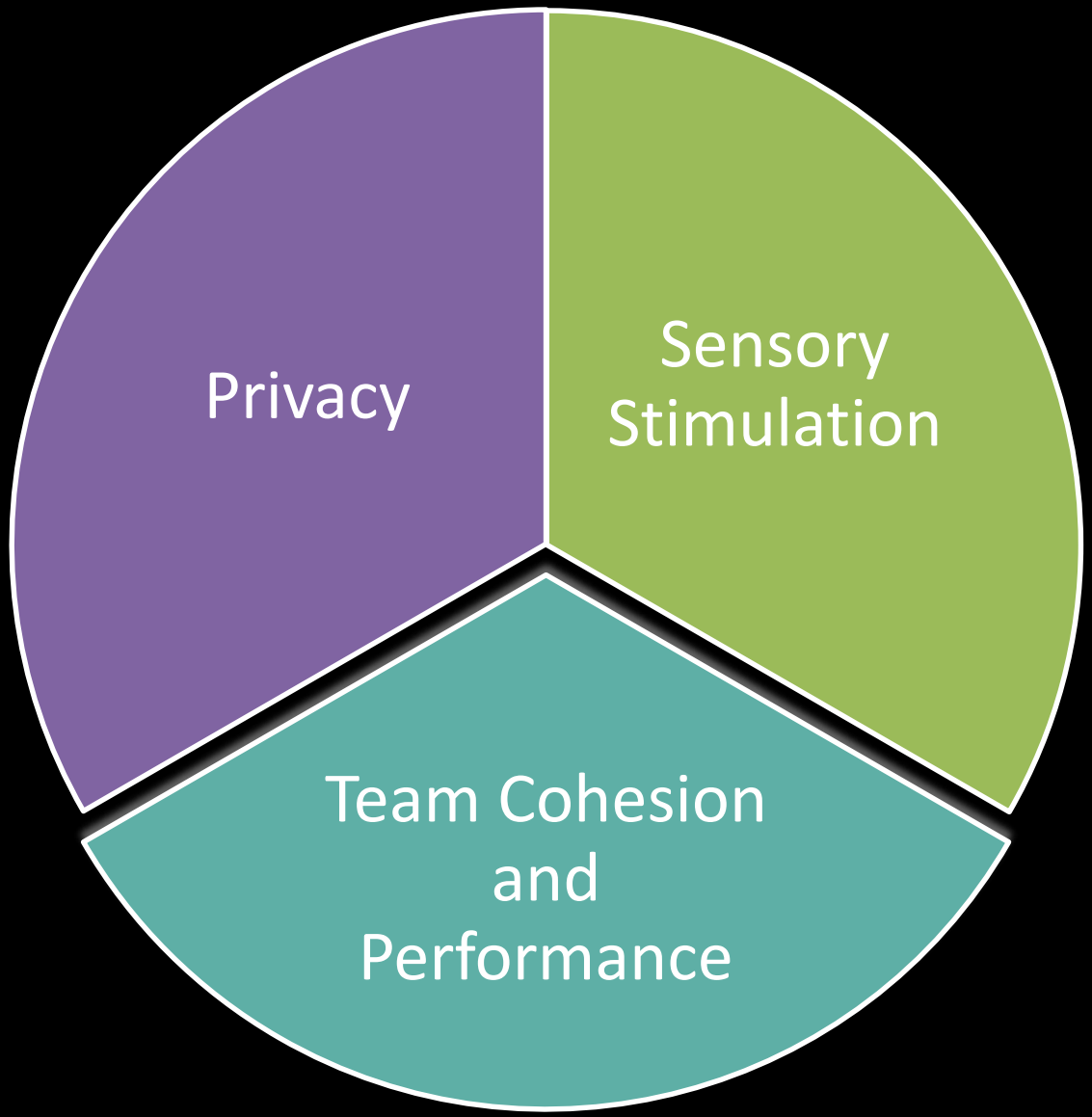
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Team Cohesion and Performance

Cohesive teams perform better (Grice & Katz, 2005)

- Effective teamwork increases likelihood of recovery from errors (Baker et al., 2006; Shapiro et al., 2004)
- Team skills training increases team and individual performance, and reduces error rates (Arthur et al., 2003; Baker et al., 2006)
- Cohesive teams are more psychologically resilient to stress (Palinkas, 1991)
- Negative impacts of interpersonal stressors on performance increase as duration increases (Halbesleben & Bowler, 2007; Rasmussen & Jeppesen, 2006)

How can the vehicle facilitate team cohesion and performance?

- Example: Group spaces can accommodate all team members at the same time; work stations designed to facilitate more than one team member working on a task

Team Cohesion and Performance

What assessments/studies are needed?

- Determine the right set of countermeasures and tools for future crews, in terms of quantity, dosage

Task by task assessment relative to the vehicle via:

- Review of specifications
- Test through virtual reality
- Test in a mock-up

- Measure team outcomes in a research study
- Require long duration
- Require high-fidelity analog: restricted volume, isolation, confinement